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NASA-15050 (June 2004)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA

Superseding NASA-15050 (May 2004)

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SECTION 15050

BASIC MECHANICAL MATERIALS AND METHODS

06/04

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers standard basic mechanical work and should be supplemented by use of other mechanical sections as required.

Drawings should show detailed upstream and downstream piping anchor provisions.

Flexible metallic pipe should be installed vertically to keep dirt out of convolutions.

Design detail and specification for each installation shall be coordinated with the manufacturer to ensure that length, stiffness of hose, and slack are suitable for the intended offset, travel, and imposed service under normal and shock conditions.

Drawings shall indicate use for main steamline dripping where amount of expansion and contraction is such that movement cannot be readily accommodated by piping configuration, with excessive stress on pressurized components or where there is a tendency to cause leaks at connections to mains. Tunnels, trenches, manholes, and above-ground steamlines are prime locations; pressure rating shall provide for water-hammer shock. This specification is limited to 1/2 inch through 1 inch 15 millimeter through 25 millimeter. Use welded pipe, valve, and hole connections wherever possible. Provide a welded end steam strainer upstream of hose to prevent welding bead penetration of bellows upon start up. Wherever possible, flexible metal steam hose should be installed vertically.

Drawings should show, or specifications should be supplemented to include, calculated movement of piping, operating pressure and temperature ranges, fluid velocity, piping anchor and guiding provisions, limit stops, installation length, end connections, and special conditions such as angular

displacement and vibration analysis in one or more planes.

Finned-tube radiation expansion joints are included under "Finned-Tube Radiation" in Section 15765 FINNED TUBE RADIATION.

This specification does not include slip-type expansion joints or ball joints.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

****

The publications listed below form a part of this section to the extent referenced:

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2001) Manual of Steel Construction Load and Resistance Factor Design

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B40.1	(1991; R 1997) Gauges - Pressure Indicating Dial Type - Elastic Element

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992; R 2003) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.8	(1991; 8th Ed) Welding Handbook; Volume Two - Welding Processes

ASME INTERNATIONAL (ASME)

ASME A112.18.1	(2003) Plumbing Fixture Fittings
ASME A112.19.2M	(1998) Vitreous China Plumbing Fixtures Supplement 1-June 2000
ASME B1.20.7	(1991; R 1998) Hose Coupling Screw Threads (Inch)
ASME B1.21M	(1997) Metric Screw Threads - MJ Profile
ASME B16.1	(1998) Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.11	(2002) Forged Steel Fittings, Socket-Welding and Threaded
ASME B16.22	(2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.25	(1997) Buttwelding Ends
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1998) Malleable Iron Threaded Fittings Classes 150 and 300
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B16.4	(1998) Gray Iron Threaded Fittings Classes 125 and 250
ASME B16.5	(1996) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.3	(2002) Process Piping
ASME B36.10M	(2000) Welded and Seamless Wrought Steel Pipe
ASME BPVC SEC IX	(2001) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2001) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM A 105/A 105M	(2003) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A 106	(2002) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 126/A 126M	(1995) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 183	(2003) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A 197/A 197M	(2000) Standard Specification for Cupola Malleable Iron
ASTM A 216/A 216M	(1993; R 2003) Standard Specification for

	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A 234/A 234M	(2003) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures
ASTM A 276	(2004) Standard Specification for Stainless Steel Bars and Shapes
ASTM A 278	(1993) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 Degrees F
ASTM A 278M	(2001) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 345 Degrees C (Metric)
ASTM A 307	(2003) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 312/A 312M	(2003) Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 480/A 480M	(2004) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A 53/A 53M	(2002) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 563	(2004) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 563M	(2003) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A 6/A 6M	(2004a) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A 74	(2004) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM B 32	(2003) Standard Specification for Solder Metal
ASTM B 370	(2003) Standard Specifications for Copper Sheet and Strip for Building Construction
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 749	(2003) Standard Specification for Lead and

	Lead Alloy Strip, Sheet and Plate Products
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM B 88M	(2003) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C 109/C 109M	(2002) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C 404	(2003) Standard Specification for Aggregates for Masonry Grout
ASTM C 476	(2002) Standard Specification for Grout for Masonry
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 564	(2003a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 67	(2003a) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C 920	(2002) Standard Specification for Elastomeric Joint Sealants
ASTM D 2000	(2003a) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 2308	(2002) Standard Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable
ASTM E 1	(2003a) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E 814	(2002) Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM F 104	(2003) Standard Classification System for Nonmetallic Gasket Materials
ASTM F 568M	(2002) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

FLUID SEALING ASSOCIATION (FSA)

FSA-0017	(1995) Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook, 6th Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 515	(1997) Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-125	(2000) Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves
MSS SP-58	(2002) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67	(2002) Butterfly Valves
MSS SP-69	(2002) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1998) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1997) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(1999) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-85	(2002) Cast Iron Globe and Angle Valves Flanged and Threaded Ends

U.S. DEPARTMENT OF DEFENSE (DOD)

MS MIL-C-18480	(1987b) Coating Compound, Bituminous, Solvent, Coal-Tar Base
MS MIL-E-17813	(1992f) Expansion Joints, Pipe, Metallic Bellows

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS FF-S-325	(Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)

UNDERWRITERS LABORATORIES (UL)

UL 1479	(2003) UL Standard for Safety Fire Tests of Through-Penetration Fire Stops

1.2 GENERAL REQUIREMENTS

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NOTE: If Section 15003 GENERAL MECHANICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the first paragraph deleted.

If Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 15055 WELDING MECHANICAL is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.

****

[Section 15003 GENERAL MECHANICAL PROVISIONS applies to work specified in this section.]

[Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT applies to work specified in this section.]

[Section 15055 WELDING MECHANICAL applies to work specified in this section.]

Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute Contractor's acceptance of the existing conditions.

Equipment Foundation Data for piping systems shall include plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

Fabrication Drawings shall be submitted for pipes, valves and specialties consisting of fabrication and assembly details to be performed in the factory.

Material, Equipment, and Fixture Lists shall be submitted for pipes, valves and specialties including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. A complete list of construction equipment to be used shall be provided.

Manufacturer's Standard Color Charts shall be submitted for pipes, valves and specialties showing the manufacturer's recommended color and finish selections.

Listing of Product Installations for piping systems shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

As-Built Drawings shall be submitted for pipes, valves and accessories providing current factual information including deviations and amendments to the drawings, and concealed and visible changes in the work.

Connection Diagrams shall be submitted for pipes, valves and specialties indicating the relations and connections of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Coordination Drawings shall be submitted for pipes, valves and specialties showing coordination of work between different trades and with the structural and architectural elements of work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between various trades.

1.3 SUBMITTALS

****
NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.
****

The following shall be submitted in accordance with Section 01330, SUBMITTAL PROCEDURES in sufficient detail to show full compliance with the specification:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for construction equipment to be used.

SD-02 Shop Drawings

The following shall be submitted for pipes, valves and specialties showing conformance with the referenced standards contained within this section.

As-Built Drawings
Connection Diagrams
Coordination Drawings
Fabrication Drawings

Installation Drawings shall be submitted for pipes, valves and specialties in accordance with the paragraph entitled, "Pipe Installation," of this section.

SD-03 Product Data

Equipment and performance data shall be submitted for the following items consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis.

Manufacturer's catalog data shall be submitted for the following items:

Pipe and Fittings
Piping Specialties
Valves
Miscellaneous Materials
Supporting Elements

Equipment Foundation Data shall be in accordance with paragraph entitled, "General Requirements," of this section.

SD-04 Samples

Manufacturer's Standard Color Charts shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-05 Design Data

Design analysis and calculations shall be submitted for the following items consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Data shall also include pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

Pipe and Fittings
Piping Specialties
Valves

SD-06 Test Reports

Test reports on the following tests shall be submitted in accordance with paragraph entitled, "Piping Installation," of this section.

Hydrostatic Tests
Air Tests
Valve-Operating Tests
Drainage Tests
Pneumatic Tests
Non-Destructive Electric Tests
System Operation Tests

SD-07 Certificates

Listing of Product Installations for piping systems shall be submitted verifying proper qualifications.

Records of Existing Conditions shall be submitted by the Contractor prior to start.

Certificates shall be submitted for the following in accordance with paragraph entitled, "Pipe Installation," of this section.

Surface Resistance
Shear and Tensile Strengths
Temperature Ratings
Bending Tests
Flattening Tests
Transverse Guided Weld Bend Tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be submitted in accordance with paragraph entitled, "Operation and Maintenance,"

of this section.

PART 2 PRODUCTS

2.1 ELECTRICAL HEAT TRACING

Heat trace systems for pipes, valves, and fittings shall be in accordance with IEEE Std 515 and shall be UL listed. System shall consist of all necessary components, including heaters and controls to prevent freezing.

Self-regulating heaters shall consist of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Heater shall be able to be crossed over itself without overheating and shall be approved before used directly on plastic pipe. Heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D 2308.

[For installation on plastic piping, the heater shall be applied using aluminum tape. Heater shall have an outer braid of tinned-copper and an outer jacket of modified polyolefin in accordance with ASTM D 2308, to provide a good ground path and to enhance the heater's ruggedness.]

****

NOTE: Self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 40 degrees F 4 degrees C pipe temperature operation to 150 degrees F 66 degrees C pipe temperature operation.

****

Heater shall have a self-regulating factor of at least [90] [_____] percent, in order to provide energy conservation and to prevent overheating.

Heater shall operate on line voltages of [120] [208] [220] [240] [277] volts without the use of transformers.

****

NOTE: Required heater output rating is in watts per foot at 50 degrees F meter at 10 degrees C. Heater selection based on one-inch 25 millimeter fiberglass insulation on metal piping.

****

Heater shall be sized according to the following table:

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
3 inches or less	5 watts per foot (wpf)	5 wpf
4 inch	5 wpf	8 wpf
6 inch	8 wpf	8 wpf
8 inch	2 strips/5 wpf	2 strips/8 wpf
12 inch to 14 inch	2 strips/8 wpf	2 strips/8 wpf

Pipe Size (DN) (Millimeter Diameter)	Minus 23 degrees C	Minus 29 degrees C
80 or less	16 watts per meter (wpm)	16 watts per meter (wpm)

Pipe Size (DN) (Millimeter Diameter)	Minus 23 degrees C	Minus 29 degrees C
100	16 wpm	26 wpm
150	26 wpm	26 wpm
200	2 strips/16 wpm	2 strips/26 wpm
300 to 356	2 strips/26 wpm	2 strips/26 wpm

System shall be controlled by an ambient sensing thermostat set at 40 degrees F 4 degrees C either directly or through an appropriate contactor.

2.2 PIPE AND FITTINGS

2.2.1 Type BCS, Black Carbon Steel

****

NOTE: This pipe is applicable for chilled, hot, dual-temperature, and cooling-tower water.

****

Pipe (1/8 through 12 inches) (DN6 through DN300) shall be Schedule 40 black carbon steel, conforming to ASTM A 53/A 53M.

Pipe (1/8 through 10 inches) (DN6 through DN250) shall be Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53/A 53M, [Type E, Grade B (electric-resistance welded)] [Type S (seamless)]. Grade A should be used for permissible field bending, in both cases.

Pipe (12 through 24 inches) (DN300 through DN610) shall be 0.375-inch 9.52 millimeter wall seamless black carbon steel, conforming to ASTM A 53/A 53M, [Type E, Grade B (electric-resistance welded)] [Type S (seamless)].

Fittings (2 inches and under) (DN50 and under) shall be 150-pounds per square inch, gage (psig) 1034 kilopascal working steam pressure (wsp) banded black malleable iron screwed, conforming to ASTM A 197/A 197M and ASME B16.3.

Unions (2 inches and under) (DN50 and under) shall be 250 pounds per square inch, wsp 1724 kilopascal (250 psi) female, screwed, black malleable iron with brass-to-iron seat, and ground joint, conforming to ASME B16.39.

Fittings (2-1/2 inches and over) (DN65 and over) shall be Steel butt weld, conforming to ASTM A 234/A 234M and ASME B16.9 to match pipe wall thickness.

Flanges (2-1/2 inches and over) (DN65 and over) shall be 150-pound 1034 kilopascal (150-pound) forged-steel conforming to ASME B16.5, welding neck to match pipe wall thickness.

2.2.2 Type BCS-125, (125-psi Service) (862 kilopascal Service)

****

NOTE: This pipe is applicable for steam- and condensate-piping systems at pressures less than 125 pounds per square inch (psi) 862 kilopascal. Avoid screwed-end connections in condensate piping wherever possible. See Section 15106 FERROUS PIPE AND FITTINGS for black carbon steel pipe for higher pressure ratings.

****

Pipe (1/8 through 1-1/2 inches) (DN6 through DN40) shall be Schedule 40 steam, Schedule 80 condensate, furnace butt weld, black carbon steel, conforming to ASTM A 53/A 53M, Type F (furnace butt welded, continuous welded) and ASME B36.10M.

Pipe (2 through 10 inches) (DN50 through DN250) shall be Schedule 40 steam, Schedule 80 condensate, seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53/A 53M [Type E, Grade B (electric-resistance welded)] [Type S (seamless)] and ASME B36.10M.

****

NOTE: For condensate piping, modify following (for 12 inches DN300 and over) to schedule 40 or schedule 80, if necessary.

****

Pipe (12 through 24 inches) (DN300 through DN610) shall be 0.375-inch 9.52 millimeter wall, [seamless] [electric-resistance] welded black carbon steel, conforming to ASTM A 53/A 53M [Type E, Grade B (electric-resistance welded)] [Type S (seamless) and ASME B36.10M].

[Fittings (2 inches and under) (DN50 and under) shall be 125-psig 862 kilopascal wsp, cast iron, screwed end, conforming to ASTM A 126/A 126M Class A and ASME B16.4.]

[Fittings (2 inches and under) (DN50 and under) shall be 150-psig 1034 kilopascal wsp banded black malleable iron screwed, conforming to ASTM A 197/A 197M and ASME B16.3.]

[Fittings (1 through 2 inches) (DN25 through DN50) shall be 2,000-or 3,000-psi 14 or 21 megapascal water, oil, or gas (wog) to match pipe wall, forged carbon steel socket weld, conforming to ASTM A 105/A 105M and ASME B16.11.]

[Fittings (2 inches and under) (DN50 and under) shall be 125-psig 862 kilopascal wsp, cast iron, screwed end, conforming to ASTM A 126/A 126M Class A and ASME B16.4.]

[Fittings (2-1/2 inches and over) (DN65 and over) shall be wall thickness to match pipe, long radius butt weld, black carbon steel, conforming to ASTM A 234/A 234M, Grade WPB and ASME B16.9.]

[Couplings (2 inches and under) (DN50 and under) shall be commercial standard weight for Schedule 40 pipe and commercial extra heavy weight for Schedule 80 pipe, black carbon steel where threaded, and 2,000-or 3,000-psi 14 or 21 megapascal wog forged carbon steel, conforming to ASTM A 105/A 105M and ASME B16.11, where welded.]

[Flanges (2-1/2 inches and over) (DN65 and over) shall be 150-pound, 1035 kilopascal, forged carbon-steel welding neck, with raised face or flat face and concentric serrated finish, conforming to ASTM A 105/A 105M and ASME B16.5.]

[Grooved pipe couplings and fittings shall conform to paragraph entitled, "Grooved Pipe Couplings and Fittings."]

2.2.3 Type GCS, Galvanized Carbon Steel

****
NOTE: This pipe is applicable for potable water and rain water leader systems.
****

Pipe (1/2 through 10 inches, and where indicated) (DN15 through DN250), and where indicated shall be Schedule 40 seamless or electric-resistance welded galvanized steel conforming to ASTM A 53/A 53M, Type E, Grade B (electric-resistance welded) or Type S (seamless).

Pipe (12 inches and over) (DN300 and over) shall be 0.375-inch 9.52 millimeter wall, seamless, galvanized steel, conforming to ASTM A 53/A 53M, Grade B.

Fittings (2 inches and under) (DN50 and under) shall be 150-psig 1034 kilopascal wsp banded galvanized malleable iron screwed, conforming to ASTM A 197/A 197M and ASME B16.3.

Unions (2 inches and under) (DN50 and under) shall be 150-psig 1034 kilopascal wsp female, screwed, galvanized malleable iron with brass-to-iron seat and ground joint.

Fittings (2-1/2 inches and over) (DN65 and over) shall be 125-psig 862 kilopascal wsp cast-iron flanges and flanged fittings, conforming to ASTM A 126/A 126M, Class A and ASME B16.1.

Grooved pipe couplings and fittings shall conform to paragraph entitled, "Grooved Pipe Couplings and Fittings."

Contractor has the option of using 150-psig 1034 kilopascal wsp banded galvanized malleable iron screwed fittings, conforming to ASTM A 197/A 197M and ASME B16.3.

2.2.4 Type GCS-DWV, Galvanized Steel Drain, Waste and Vent

****
NOTE: Nonferrous piping exposed to view in finished spaces and normally chrome plated is specified in Section 15410 PLUMBING FIXTURES Select A53 pipe where bending and flattening tests are required.
****

Pipe (all sizes) shall be Schedule 40 [seamless] [electric-resistance welded] galvanized carbon steel, conforming to ASTM A 53/A 53M, Grade A.

Furnace butt weld pipe is acceptable for sizes less than 2 inches DN50.

[Risers 3 inches DN80 and larger shall be Type CISP-DWV.]

[Fittings shall be galvanized, [coated] [uncoated], screwed, cast iron, recessed pattern drainage fittings, conforming to ASTM A 126/A 126M.]

[Long radius fittings shall be used wherever space permits. Short-turn tees, branches, and ells may be used for vent piping and connections of branch lines to battery fixtures, except wall-hung water closets.]

2.2.5 Type CISP-DWV, Cast-Iron Drain, Waste and Vent

****
NOTE: When project requires risers 3 inches DN80 and larger, include Type CISP-DWV materials specification.
****

Soil pipe drain, waste, and vent bell-and-spigot type pipe shall be cast iron, conforming to ASTM A 74. Joints shall be calked and leaded in lines where necessary to provide proper leaktight support and alignment; other-wise joints may be two-gasket system type chloroprene, conforming to ASTM C 564. Pipe class shall be extra heavy (CISP-DWV-XH).

2.2.6 Type CPR, Copper

****
NOTE: Copper pipe above ground and below ground is acceptable for chilled, hot, dual-temperature, cooling-tower water, and potable-water systems.
****

2.2.6.1 Type CPR-A, Copper Above Ground

Tubing (2 inches and under) (DN50 and under) shall be seamless copper tubing, conforming to ASTM B 88, ASTM B 88M, Type L (hard-drawn for all horizontal and all exposed vertical lines, annealed for concealed vertical lines).

Fittings (2 inches and under) (DN50 and under) shall be 150-psig 1034 kilopascal wsp wrought-copper solder joint fittings conforming to ASME B16.22.

Unions (2 inches and under) (DN50 and under) shall be 150-psig 1034 kilopascal wsp wrought-copper solder joint, conforming to ASME B16.22.

[Brazing rod shall be Classification BCuP-5, conforming to AWS A5.8.]

[Solder shall be 60-40 tin-antimony, alloy Sb-5, conforming to ASTM B 32.]

2.2.6.2 Type CPR-U, Copper Under Ground

****
NOTE: For sizes under 3 inches DN80.
****

Piping shall be Type K seamless copper tube, conforming to ASTM B 88 ASTM B 88M. Socket-joint fittings shall be wrought copper, conforming to ASME B16.22. Fittings for connection to corporation cocks shall be cast bronze, flared-type, conforming to ASME B16.26. Joints shall be brazed.

2.2.6.3 Type CPR-INS, Copper Under Ground Insulated

****
NOTE: Type CPR-INS material is commercially available in sizes to and including 4 inches DN105 OD.

Since pipe is protected from soil by insulation

system, Type L copper tube may be used if suitable for water carried at a cost saving of 10 percent.

Type CPR-INS material may be used for hot water supply and return connected to tunnel mains.

****

Piping shall be insulated Type K seamless copper tube conforming to ASTM B 88 ASTM B 88M. Socket-joint fittings shall be wrought copper, conforming to ASME B16.22. Joints shall be brazed.

Insulation shall be not less than 2 inches DN50 thick, suitable for continuous service temperatures of not less than 250 degrees F 121 degrees C. Insulation shall be factory-molded, closed-cell polyurethane foam of not less than 2.5 pounds per cubic foot 40 kilogram per cubic meter density. Insulation shall be waterproofed with an extruded rigid Type II virgin polyvinylchloride, with minimum wall thickness of 60 mils through 4 inches 1.52 millimeter through 102 millimeter outside diameter, 85 mils through 6.625 inches 2.16 millimeter through 168.28 millimeter and 110 mils through 12.750 inches 2.79 millimeter through 273 millimeter. Fitting covers shall be fabricated from same materials and thickness as adjacent pipe covering according to the manufacturer's directions.

2.2.7 Grooved Pipe Couplings and Fittings

Couplings shall have a housing, fabricated in two or more parts, of black, ungalvanized malleable iron castings. Coupling gasket shall be molded synthetic rubber, conforming to ASTM D 2000. Coupling bolts shall be oval-neck, track-head type, with hexagonal heavy nuts conforming to ASTM A 183.

All pipe fittings used with couplings shall be fabricated of black, ungalvanized malleable iron castings. Where a manufacturer's standard-size malleable iron fitting pattern is not available, approved fabricated fittings may be used.

Fittings shall be fabricated from Schedule 40 or 0.75-inch 19 millimeter (0.75-inch) wall ASTM A 53/A 53M, Grade B seamless steel pipe; long radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A 234/A 234M and ASME B16.9.

2.3 PIPING SPECIALTIES

2.3.1 Air Separator

Air separated from converter discharge water shall be ejected by a reduced-velocity device vented to the compression tank.

[Commercially constructed separator shall be designed and certified to separate not less than 80 percent of entrained air on the first passage of water and not less than 80 percent of residual on each successive pass. Shop drawings shall detail piping connections proposed for this work.]

[Air separator shall be carbon steel, designed, fabricated, tested, and stamped in conformance with ASME BPVC SEC VIII D1 for service pressures not less than 125 psi 862 kilopascal.]

2.3.2 Air Vents

[Manual air vents shall be 3/8-inch 10 millimeter globe valves.]

****
NOTE: This size vent is suitable for most systems, and will pass 20 cubic feet of free air per minute 9.40 liter per second of free air at a system pressure of 125 psi 862 kilopascal. Where a system must be filled at a certain rate, larger vents or a multiple assembly with safety features should be used.
****

[Automatic air vents on pumps, mains, and where indicated shall be of ball-float construction. Vent inlet shall be not less than 3/4-inch ips DN20, and the outlet shall be not less than 1/4-inch ips 8 millimeter. Orifice shall be 1/8 inch 3 millimeter. Trim shall be corrosion-resistant steel conforming to [ASTM A 276] [ASTM A 480/A 480M]. Vent shall be fitted with try-cock. Vent shall discharge air at any pressure to 150 psi 1034 kilopascal. Outlet shall be copper tube routed.]

2.3.3 Compression Tank

Compression tank shall be designed, fabricated, tested, and stamped for a working pressure of not less than 125 psi 862 kilopascal in accordance with ASME BPVC SEC VIII D1. Tank shall be hot-dip galvanized after fabrication to produce not less than 1.5 ounces 51 grams of zinc coating per square foot meter of single-side surface.

Tank accessories shall include red-lined gage-glass complete with glass protectors and shutoff valves, air charger and drainer, and manual vent.

2.3.4 Dielectric Connections

Dissimilar pipe metals shall be electrically insulated from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

2.3.5 Expansion Vibration Isolation Joints

****
NOTE: Drawings should show detailed piping anchor provisions where expansion vibration isolation joints are used.

This joint may also serve as a dielectric connector.
****

Single or multiple arch-flanged expansion vibration isolation joints shall be constructed of steel-ring reinforced chloroprene-impregnated cloth materials. Joint shall be designed to absorb the movement of the pipe sections in which installed with no detrimental effect on the pipe or connected equipment. Flanges shall be backed with ferrous-metal backing rings. Control rod assemblies shall be provided to restrict joint movement. All nonmetallic exterior surfaces of the joint shall be coated with chlorosulphinated polyethylene. Grommets shall be provided in limit bolt hole to absorb noise transmitted through the bolts.

****
NOTE: If other elastomers are substituted for chloroprene, temperature limits may be lowered to 180 degrees F 82 degrees C or less.
****

Joints shall be suitable for continuous-duty working temperature of at least 250 degrees F 121 degrees C.

****
NOTE: Select the following paragraph where solids accumulating in arch would cause cutting of carcass. Note that all movements will be reduced by 50 percent.
****

Arches shall be filled with soft chloroprene.

Joint, single-arch, movement limitations and size-related, pressure characteristics shall conform to FSA-0017.

2.3.6 Flexible Pipe

****
NOTE: Drawings should show detailed upstream and downstream piping anchor provisions and location with respect to axis of motion where flexible pipe is used.

Grooved couplings and vibration-isolated pipe hangers should be considered.

Flexible pipe may also serve as a dielectric connector.

Select following paragraph for manufacturer's standard-service pipe.
****

Flexible pipe vibration and pipe-noise eliminators shall be constructed of wire-reinforced, rubber-impregnated cloth and cord materials and shall be flanged. Flanges shall be backed with ferrous-metal backing rings. Service pressure-rating shall be minimum 1.5 times actual service. Surge pressure shall be at 180 degrees F 82 degrees C.

****
NOTE: Anticipated life of chloroprene units at 250 degrees F 121 degrees C is 5 to 10 years.
****

Flexible pipe vibration and pipe noise eliminators shall be constructed of wire-reinforced chloroprene-impregnated cloth and cord materials and they shall be flanged. Flanges shall be backed with ferrous-metal backing rings. Nonmetallic exterior surfaces of the flexible pipe shall be coated with an acid- and oxidation-resistant chlorosulphinated polyethylene. Flexible pipe shall be rated for continuous duty at 130 psi and 250 degrees F 896 kilopascal and 121 degrees C.

Unit pipe lengths, face-to-face, shall be not less than the following:

****
NOTE: The following lengths are basic recommendations: each application should be reviewed for optimum length.
****

INSIDE DIAMETER	UNIT PIPE LENGTH
[To 2-1/2 inches, inclusive	12 inches
3 to 4 inches, inclusive	18 inches
5 to 12 inches, inclusive	24 inches]
[To 3 inches, inclusive	18 inches
4 to 10 inches, inclusive	24 inches
12 inches and larger	36 inches]

INSIDE DIAMETER (DN)	UNIT PIPE LENGTH
[To 65, inclusive	305 millimeter
80 to 100, inclusive	450 millimeter
125 to 300, inclusive	600 millimeter]
[To 80, inclusive	450 millimeter
110 to 250, inclusive	600 millimeter
300 and larger	914 millimeter]

2.3.7 Flexible Metallic Pipe

Flexible pipe shall be the bellows-type with wire braid cover and shall be designed, constructed, and rated in accordance with the applicable requirements of ASME B31.3.

Working pressure minimum rating shall be [50] [100] psi at 300 degrees F [345] [690] kilopascal at 149 degrees C.

[Minimum burst pressure shall be four times working pressure at 300 degrees F 149 degrees C. Bellows material shall be AISI Type 316L corrosion-resistant steel. Braid shall be AISI 300 series corrosion-resistant steel wire.]

[Welded end connections shall be Schedule 80 carbon steel pipe, conforming to ASTM A 106, Grade [B] [C].]

[Threaded end connections shall be hex-collared Schedule 40, AISI Type 316L corrosion-resistant steel, conforming to ASTM A 312/A 312M.]

[Flanged end connection rating and materials shall conform to specifications for system primary-pressure rating.]

2.3.8 Flexible Metal Steam Hose

Hose shall be bellows type with wire braid cover and shall be designed, constructed, and rated in accordance with the applicable requirements of ASME B31.3.

Working steam pressure rating shall be 125 psi at 500 degrees F 862 kilopascal at 260 degrees C.

[Minimum burst pressure shall be nine times working steam pressure at 300 degrees F 149 degrees C.]

Bellows material shall be AISI Type 316L corrosion-resistant steel. Braid shall be AISI Type 300-series corrosion-resistant steel wire.

[Welded end connections shall be Schedule 80 carbon steel pressure tube, conforming to ASTM A 106, Grade [B] [C].]

[Threaded end connections shall be hex-collared Schedule 40, AISI Type 316L corrosion-resistant steel, conforming to ASTM A 312/A 312M.]

[Flanged end connection rating and materials shall conform to specifications for system primary-pressure rating.]

2.3.9 Metallic Expansion Joints

[Expansion joints shall be metallic-bellows-type, conforming to MS MIL-E-17813.]

[Expansion joints shall be Type I (corrugated bellows, unreinforced), [Class 1 (single bellows, expansion joint)], [Class 2 (double bellows, expansion joint)].]

Joints shall be designed and constructed to absorb all of the movements of the pipe sections in which installed, with no detrimental effect on pipe or supporting structure.

Joints shall be rated, designed, and constructed for pressures to 125 psig 862 kilopascal and temperatures to 500 degrees F 260 degrees C.

Joints shall have a designed bursting strength in excess of [four] [_____] times their rated pressure.

Joints shall be capable of withstanding a hydrostatic test of 1.5 times their rated pressure while held at their uncompressed length without leakage or distortion that may adversely affect their life cycle.

Life expectancy shall be not less than 10,000 cycles.

Movement capability of each joint shall exceed calculated movement of piping by [100] [_____] percent.

Bellows and internal sleeve material shall be AISI Type 304, 304L, or 321 corrosion-resistant steel.

End connections shall require no field preparation other than cleaning.

[Butt weld end preparation of expansion joints shall conform to the same codes and standards requirements as applicable to the piping system

materials at the indicated joint location.]

[Flanges of flanged-end expansion joints shall conform to the same codes and standard requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.]

Joints, 2-1/2 inches DN65 and smaller, shall have internal guides and limit stops.

Joints, 3 inches DN80 and larger, shall be provided with removable external covers, internal sleeves, and purging connection. Sleeves shall be sized to accommodate lateral clearance required, with minimum reduction of flow area, and with oversized bellows where necessary. When a sleeve requires a gasket as part of a locking arrangement, the gasket shall be provided by the manufacturer. Joints without purging connection may be provided; however, these shall be removed from the line prior to, or not installed until, cleaning operations are complete.

[Cylindrical end portion of the reinforced bellows element shall be provided with a thrust sleeve of sufficient thickness to bring that portion within applicable code-allowable stress. Sleeve shall provide 360 degrees support for the element and end-reinforcing ring.]

[Expansion joints shall have four, equidistant, permanent tram points clearly marked on each joint end. Points shall be located to prevent obliteration during installation. Distance between tram points indicating installed lengths shall be included in shop drawings. Overall dimension after joint installation shall be subject to approval.]

Each expansion joint shall have adjustable clamps or yokes provided at quarter points, straddling the bellows. Overall joint length shall be set by the manufacturer to maintain joints in manufacturer's recommended position during installation.

****

NOTE: Pipe lines containing expansion joints must be securely anchored to completely resist the thrust due to the pressure acting on the full internal area of the corrugations. They must also be properly guided to prevent misalignment of the joint. Details of anchors and guides must be correlated for each application.

****

Each joint shall be permanently and legibly marked with the manufacturer's name or trademark and serial number; the size, series, or catalog number; bellows material; and directional-flow arrow.

2.3.10 Hose Faucets

****

NOTE: Normally delete vacuum breaker when faucets are installed in nonpotable-water lines.

****

Hose faucets shall be constructed with 1/2 inch 15 millimeter male inlet threads, hexagon shoulder, and 3/4 inch 20 millimeter hose connection, conforming to ASME A112.18.1. Hose-coupling screw threads shall conform to ASME B1.20.7 ASME B1.21M.

Vandalproof, atmospheric-type vacuum breaker shall be provided on the discharge of all potable water lines.

2.3.11 Pressure Gages

Pressure gages shall conform to ANSI B40.1 and to requirements specified herein. Pressure-gage size shall be 3-1/2 inches 90 millimeter nominal diameter. Case shall be corrosion-resistant steel, conforming to any of the AISI 300 series of ASTM A 6/A 6M, with an ASM No. 4 standard commercial polish or better. Gages shall be equipped with adjustable red marking pointer and damper-screw adjustment in inlet connection. Service-pressure reading shall be at midpoint of gage range. All gages shall be Grade B or better and be equipped with gage isolators.

****
NOTE: Retain the following paragraph only if pressure gages are used on steam piping.
****

[Steam gages shall be fitted with black steel syphons and steam service pressure-rated gage cocks or valves.]

2.3.12 Sight-Flow Indicators

Sight-flow indicators for pressure service on 3-inch ips 80 millimeter and smaller shall be constructed of bronze with specially treated single- or double-glass sight windows and shall have a bronze, nylon, or tetrafluoroethylene rotating flow indicator mounted on an AISI Type [304] [316] corrosion-resistant steel shaft. Body may have screwed or flanged end. Assembly shall be pressure- and temperature-rated for the applied service. Flapper flow-type indicators are not acceptable.

2.3.13 Sleeve Couplings

Sleeve couplings for plain-end pipe shall consist of one steel middle ring, two steel followers, two chloroprene or Buna-N elastomer gaskets, and the necessary steel bolts and nuts.

2.3.14 Thermometers

Thermometers shall conform to ASTM E 1, except for being filled with a red organic liquid. Thermometers shall be an industrial pattern armored glass model, (well-threaded and seal-welded). Thermometers installed 6 feet 1800 millimeter or higher above the floor shall have an adjustable angle body. Scale shall be not less than 7 inches 180 millimeter long. Case face shall be manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Thermometer range shall be [_____]. Thermometers shall be provided with nonferrous separable wells. Lagging extension to accommodate insulation thickness shall be provided.

2.3.15 Pump Suction Strainers

****
NOTE: To preclude cavitation, check the following conditions prior to specifying: NPSH, flow rate, open area, screen size, and pressure drop across strainer.
****

Strainer body shall be cast iron, rated for not less than 25 psig at 100 degrees F 172 kilopascal at 38 degrees C, with flanges conforming to ASME B16.1, Class 125. Strainer construction shall be such that there is a machined surface joint between body and basket that is normal to the centerline of the basket.

Minimum ratio of open area of each basket to pipe area shall be 3 to 1. Basket shall be AISI 300 series corrosion-resistant steel wire mesh with perforated backing.

Mesh shall be capable of retaining all particles larger than 1,000 micrometer, with a pressure drop across the strainer body of not more than 0.5 psi 5 kilopascal when the basket is two-thirds dirty at maximum system flow rate. Reducing fittings from strainer-flange size to pipe size shall be provided.

A [differential-pressure gage] [pressure gage with 0.25-pound 2 kilopascal graduations] fitted with a two-way brass cock shall be provided across the strainer.

Manual air vent cocks shall be provided in cap of each strainer.

2.3.16 Line Strainers, Water Service

Strainers shall be Y-type with removable basket. Strainers in sizes 2-inch ips DN50 and smaller shall have screwed ends. In sizes 2-1/2-inch ips DN65 and larger, strainers shall have flanged ends. Body working-pressure rating shall exceed maximum service pressure of system in which installed by at least 50 percent. Body shall have cast-in arrows to indicate direction of flow. All strainer bodies fitted with screwed screen retainers shall have straight threads and shall be gasketed with nonferrous metal. Strainer bodies 2-1/2-inches DN65 and larger, fitted with bolted-on screen retainers, shall have offset blowdown holes. All strainers larger than 2-1/2-inches DN65 shall be fitted with manufacturer's standard ball-type blowdown valve. Body material shall be [cast bronze conforming to ASTM B 62] [cast iron conforming to Class 30 ASTM A 278 ASTM A 278M]. Where system material is nonferrous, metal strainer body material shall be nonferrous metal.

Minimum free-hole area of strainer element shall be equal to not less than 3.4 times the internal area of connecting piping. Strainer screens shall have perforations not to exceed 0.045-inch 1.14 millimeter. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be [AISI Type [304] [316] corrosion-resistant steel] [Monel metal].

2.3.17 Line Strainers, Steam Service

Strainers shall be Y-type with removable strainer element.

Body end connections shall be flanged for all valves larger than 2 inches DN50, unless butt weld ends are specified. [Screwed] [Socket] weld shall be used for sizes 2 inches DN50 and under to suit specified piping system end connection and maintenance requirements [or be welded].

Strainers located in tunnels, trenches, manholes, and valve pits shall have welded end connections.

Body working steam pressure rating shall be the same as the primary valve rating for system in which strainer is installed, except where welded end materials requirements result in higher pressure ratings. Body shall have integral cast or forged arrows to indicate direction of flow. Strainer bodies shall be provided with blowdown valves that have discharge end plugged with a solid metal plug. Closure assembly shall be made with tetrafluoroethylene tape. Bodies fitted with bolted-on screen retainers shall have offset blowdown holes.

Body materials shall be [cast steel conforming to ASTM A 216/A 216M, Grade WCB] [forged carbon steel conforming to ASTM A 105/A 105M] [manufacturer's standard metallurgical equivalents for service pressures of 150-psi 1035 kilopascal wsp and greater, and for lower pressure ratings where welding is required] [cast iron conforming to ASTM A 126/A 126M, Class B, for service pressures 125-psi 862 kilopascal wsp and less].

Minimum free-hole area of strainer element shall be equal to not less than 3.4 times the internal area of connecting piping. Strainer screens shall have perforations not to exceed 0.020 inch 0.51 millimeter or equivalent wire mesh. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be AISI Type [304] [316] corrosion-resistant steel and shall be fitted with backup screens where necessary to prevent collapse.

2.4 VALVES

****

NOTE: Figure 1A is a one piece body.

Figure 1B is a vertically split body. with the split to one side of the ball.

Figure 1C is a top entry.

Figure 1D is a three piece body.

****

2.4.1 Ball and Butterfly Valves

Ball valves shall conform to MSS SP-72 for Figure [1A], 1 piece body [1B], vertically split body [1C], top entry [1D], three piece body and shall be rated for service at not less than 175 psig at 200 degrees F 1207 kilopascal at 93 degrees C. Valve bodies in sizes 2 inches DN50 and smaller shall be screwed-end connection-type constructed of Class A copper alloy. Valve bodies in sizes 2-1/2 inches DN65 and larger shall be flanged-end connection type, constructed of Class [D] [E] [F] material. Balls and stems of valves 2 inches DN50 and smaller shall be manufacturer's standard with hard chrome plating finish. Balls and stems of valves 2-1/2 inches DN65 and larger shall be manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plating. Balls of valves 6 inches DN150 and larger may be Class D with 900 Brinell hard chrome plating. Valves shall be suitable for flow from either direction and shall seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable. All valves shall have adjustable packing glands. Seats and seals shall be tetrafluoroethylene.

Butterfly valves shall conform to MSS SP-67. Valves shall be wafer type for mounting between specified flanges and shall be rated for 150-psig 1034 kilopascal shutoff and nonshock working pressure. Bodies shall be cast

ferrous metal conforming to ASTM A 126/A 126M, Class B, and to ASME B16.1 for body wall thickness. Seats and seals shall be of the resilient elastomer type designed for field removal and replacement.

2.4.2 Drain, Vent, and Gage Cocks

Drain, vent, and gage cocks shall be [T-head] [lever handle], ground key type, with washer and screw, constructed of polished ASTM B 62 bronze, and rated 125-psi 862 kilopascal wsp. End connections shall be rated for specified service pressure.

Pump vent cocks, and where spray control is required, shall be UL umbrella-hood type, constructed of manufacturer's standard polished brass. Cocks shall be 1/2-inch ips 15 millimeter male, end threaded, and rated at not less than 125 psi at 225 degrees F 862 kilopascal at 107 degrees C.

2.4.3 Gate Valves (GAV)

Gate valves 2 inches DN50 and smaller shall conform to MSS SP-72. Valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated shall be union-ring bonnet, screwed-end type. Packing shall be made of non-asbestos type materials. Valves shall be rising stem type.

Gate valves 2-1/2 inches DN65 and larger, shall be Type I, (solid wedge disc, tapered seats, steam rated); Class 125 (125-psig 862 kilopascal steam-working pressure at 353 degrees F 178 degrees C saturation); and 200-psig 1379 kilopascal, wog (nonshock), conforming to MSS SP-70 and to requirements specified herein. Valves shall be flanged, with bronze trim and outside screw and yoke (OS&Y) construction. Packing shall be made of non-asbestos type materials.

2.4.4 Globe and Angle Valves (GLV-ANV)

Globe and angle valves 2 inches DN50 and smaller, shall be 125-pound, 125-psi 862 kilopascal conforming to MSS SP-85 and to requirements specified herein. Valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated shall be union-ring bonnet, screwed-end type. Disc shall be free to swivel on the stem in all valve sizes. Composition seating-surface disc construction may be substituted for all metal-disc construction. Packing shall be made of non-asbestos type materials. Disk and packing shall be suitable for pipe service installed.

Globe and angle valves 2-1/2 inches DN65 and larger, shall be cast iron with bronze trim. Valve bodies shall be cast iron conforming to ASTM A 126/A 126M, Class A, as specified for Class 1 valves under MSS SP-70. Valve ends shall be flanged in conformance with ASME B16.1. Valve construction shall be outside screw and yoke (OS&Y) type. Packing shall be made of non-asbestos type materials.

2.4.5 Standard Check Valves (SCV)

Standard check valves in sizes 2 inches DN50 and smaller shall be 125-psi 862 kilopascal swing check conforming to MSS SP-71, except as otherwise specified. Lift checks shall be provided where indicated. Swing-check pins shall be nonferrous and suitably hard for the service. Discs shall be composition type. Swing-check angle of closure shall be manufacturer's standard unless a specific angle is needed.

Check valves in sizes 2-1/2 inches DN65 and larger shall be cast iron, bronze trim, swing type. Valve bodies shall be cast iron, conforming to ASTM A 126/A 126M, Class A. Valve ends shall be flanged in conformance with ASME B16.1. Swing-check pin shall be AISI Type [304] [316] or approved equal corrosion-resistant steel. Angle of closure shall be manufacturer's standard unless a specific angle is needed. Valves shall have bolted and gasketed covers.

Check valves shall be provided with [external spring-loaded] [lever-weighted], positive-closure devices and valve ends shall be [mechanical joint] [push-on] [flanged].

2.4.6 Nonslam Check Valves (NSV)

****
NOTE: The following specification is adequate for most construction situations. Where unusual hydraulic conditions occur, review closing time and in-service adjustment capability of helical-coil valve construction versus other construction.
****

Check valves at pump discharges in sizes 2 inches DN50 and larger shall be nonslam or silent-check type conforming to MSS SP-125. Valve disc or plate shall close before line flow can reverse to eliminate slam and water-hammer due to check-valve closure. Valve shall be Class 125 rated for 200-psi 1379 kilopascal maximum, nonshock pressure at 150 degrees F 66 degrees C in sizes to 12 inches DN300. Valves shall be [wafer type to fit between flanges conforming to ASME B16.1] [fitted with flanges conforming to ASME B16.1]. Valve body may be cast iron, conforming to ASTM A 278 ASTM A 278M, Class 40 or equivalent strength ductile iron. Disks shall be manufacturer's standard bronze, aluminum bronze, or corrosion-resistant steel. Pins, springs, and miscellaneous trim shall be manufacturer's standard corrosion-resistant steel. Disk and shaft seals shall be Buna-N elastomer tetrafluoroethylene.

2.5 MISCELLANEOUS MATERIALS

2.5.1 Bituminous Coating

Bituminous coating shall be a solvent cutback, heavy-bodied material to produce not less than a 12-mil 0.30 millimeter dry-film thickness in one coat, and shall be as recommended by the manufacturer to be compatible with factory-applied coating and rubber joints.

For previously coal-tar coated and uncoated ferrous surfaces underground, bituminous coating shall be solvent cutback coal-tar type, conforming to MS MIL-C-18480.

2.5.2 Bolting

Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B ASTM F 568M, Class 4.8 or above (bolts, for flanged joints in piping systems where one or both flanges are cast iron). Heavy hex-nuts shall conform to ASTM A 563 ASTM A 563M. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

2.5.3 Elastomer Calk

Polysulfide- or polyurethane-base elastomer calking material shall be two-component type, conforming to ASTM C 920.

2.5.4 Escutcheons

Escutcheons shall be manufactured from nonferrous metals and shall be chrome-plated except when AISI 300 series corrosion-resistant steel is provided. Metals and finish shall conform to ASME A112.19.2M.

Escutcheons shall be one-piece type where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. All escutcheons shall have provisions consisting of [internal spring-tension devices] [setscrews] for maintaining a fixed position against a surface.

2.5.5 Flashing

Sheet lead shall conform to ASTM B 749, [UNS Alloy Number L50049 (intended for use in laboratories and shops in general application)] [UNS Alloy Number L51121 (for use where lead sheet of high purity and improved structural strength is indicated)].

Sheet copper shall conform to ASTM B 370 and shall be of not less than 16 ounces per square foot 4.88 kilogram per square meter weight.

2.5.6 Flange Gaskets

Compressed non-asbestos sheet, conforming to ASTM F 104, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F 399 degrees C.

2.5.7 Grout

****
NOTE: When moisture or uncured concrete occurs, metallic grout may cause buildup of pressure that, under confinement, could be sufficient to misalign equipment.
****

Shrink-resistant grout shall be a premixed and packaged metallic-aggregate, mortar-grouting compound conforming to ASTM C 404 and ASTM C 476.

****
NOTE: Epoxy grout shall be specified particularly where mild chemical resistance is necessary or where oil soaking may occur.

For service with acids, polyester grouts should be specified.

Where high anchor-bolt torques (2,000 ft-lb) (2712 newton-meter) are applied, epoxy polyamides will cold-flow.
****

Shrink-resistant grout shall be a combination of premeasured and packaged epoxy polyamide or amine resins and selected aggregate mortar grouting

compound conforming to the following requirements:

Tensile strength		1,900 psi, 13.100 Megapascal, minimum
Compressive strength	ASTM C 109/C 109M	14,000 psi, 96.527 Megapascal, minimum
Shrinkage, linear		0.00012 inch per inch, 0.003 mm per millimeter, maximum
Water absorption	ASTM C 67	0.1 percent, maximum
Bond strength to minimum steel in shear minimum		1,000 psi, 6.895 Megapascal,

2.5.8 Pipe Thread Compounds

Tetrafluoroethylene tape not less than 2 to 3 mils 0.05 to 0.08 millimeter thick shall be used in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips DN25. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval by the Contracting Officer; however, no lead-containing compounds may be used in potable water systems.

2.6 SUPPORTING ELEMENTS

All necessary piping systems and equipment supporting elements shall be provided, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. All supporting elements shall be suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

Supporting elements shall conform to requirements of ASME B31.3, FS FF-S-325, MSS SP-58, and MSS SP-69 except as noted.

Attachments welded to pipe shall be made of materials identical to that of pipe or materials accepted as permissible raw materials by referenced code or standard specification.

Supporting elements exposed to weather shall be hot-dip galvanized or stainless steel. Materials shall be of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Supporting elements in contact with copper tubing shall be electroplated with copper.

Type designations specified herein are based on MSS SP-58 and MSS SP-69. Masonry anchor group-, type-, and style-combination designations shall be in accordance with FS FF-S-325. Support elements, except for supplementary steel, shall be cataloged, load rated, commercially manufactured products.

2.6.1 Building Structure Attachments

****

NOTE: Review specific instructions relative to anchor devices in support elements installation paragraph prior to selection of following text.

****

2.6.1.1 Anchor Devices, Concrete and Masonry

Anchor devices shall conform to FS FF-S-325 for the following types:

Group I - shield, expansion (lead, bolt and stud anchors)

Group II - shield, expansion (bolt anchors)

Type 2 - machine bolt expansion shield anchors

Class 2 - open-end expansion shield anchors

Style 1 - single-end expansion shield anchors

Style 2 - double-end expansion shield anchors

Group III - shield, expansion (self-drilling

tubular expansion shell bolt anchors)

Group VIII - anchors, expansion (nondrilling)

Cast-in, floor mounted, equipment anchor devices shall provide adjustable positions.

[Masonry anchor devices shall be built-in.]

Powder-actuated anchoring devices shall not be used to support any mechanical systems components.

2.6.1.2 Beam Clamps

Beam clamps shall be center-loading MSS SP-58 Type [20] [21] [28] [29] [30] [_____].

[When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, MSS SP-58 Type [19] [20] [25] [27] may be used for piping sizes 2 inches DN50 and less and for piping sizes 2 through 10 inches DN50 through DN250 provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, rod diameter shall be determined in accordance with referenced standards.]

2.6.1.3 C-Clamps

C-clamps shall not be used.

2.6.1.4 Inserts, Concrete

Concrete inserts shall be MSS SP-58 Type [18] [_____]. When applied to piping in sizes 2 inches ips DN50 and larger and where otherwise required by imposed loads, a 1-foot 305 millimeter length of 1/2-inch 13 millimeter reinforcing rod shall be inserted and wired through wing slots. Proprietary-type continuous inserts may be submitted for approval.

2.6.2 Horizontal Pipe Attachments

2.6.2.1 Single Pipes

Piping in sizes to and including 2-inch ips DN50 shall be supported by MSS SP-58 Type 6 solid malleable iron pipe rings, except that split-band-type rings may be used in sizes up to 1-inch ips DN25.

Piping in sizes through 8-inch ips DN200 inclusive shall be supported by MSS SP-58 Type [1] [3] [4] attachments.

MSS SP-58 Type 1 and Type 6 assemblies shall be used on vapor-sealed insulated piping and shall have an inside diameter larger than pipe being supported to provide adequate clearance during pipe movement.

Where thermal movement of a point in a piping system 4 inches DN100 and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch 13 millimeter, MSS SP-58 Type [41] [44 through 46] [49] pipe rolls shall be used.

Piping in sizes larger than 8-inch ips DN200 shall be supported with MSS SP-58 Type [41] [44 through 46] [49] pipe rolls.

MSS SP-58 Type 40 shields shall be used on all insulated piping. Area of the supporting surface shall be such that compression deformation of insulated surfaces does not occur. Longitudinal and transverse shield edges shall be rolled away from the insulation.

Insulated piping without vapor barrier on roll supports shall be provided with MSS SP-58 Type 39 saddles.

Spring supports shall be as indicated.

2.6.2.2 Parallel Pipes

Trapeze hangers fabricated from structural steel shapes, with U-bolts, shall be used in congested areas and where multiple pipe runs occur. Structural steel shapes shall [conform to supplementary steel requirements] [be of commercially available, proprietary design, rolled steel].

2.6.3 Vertical Pipe Attachments

Vertical pipe attachments shall be MSS SP-58 Type 8.

Shop drawing data shall include complete fabrication and attachment details of any spring supports.

2.6.4 Hanger Rods and Fixtures

Only circular cross section rod hangers may be used to connect building structure attachments to pipe support devices. Pipe, straps, or bars of equivalent strength shall be used for hangers only where approved by the Contracting Officer.

Turnbuckles, swing eyes, and clevises shall be provided as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

2.6.5 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, such supplementary steel shall be designed and fabricated in accordance with AISC 325.

PART 3 EXECUTION

3.1 PIPE INSTALLATION

Certificates shall be submitted for pipes, valves and specialties showing conformance with test requirements as contained in the reference standards contained in this section. Certificates shall verify Surface Resistance, Shear and Tensile Strengths, Temperature Ratings, Bending Tests, Flattening Tests and Transverse Guided Weld Bend Tests.

Test reports for Hydrostatic Tests, Air Tests, Valve-Operating Tests, Drainage Tests, Pneumatic Tests, Non-Destructive Electric Tests and System Operation Tests shall be provided by the Contractor, in compliance with referenced standards contained within this section.

Piping systems shall be fabricated and installed in accordance with ASME B31.3, MSS SP-69, and AWS WHB-2.8.

Installation Drawings shall be submitted for pipes, valves and specialties. Drawings shall include the manufacturer's design and construction calculations, forces required to obtain rated axial, lateral, or angular movements, installation criteria, anchor and guide requirements for equipment, and equipment room layout and design. Drawing shall specifically advise on procedures to be followed and provisions required to protect expansion joints during specified hydrostatic testing operations.

Connections between steel piping and copper piping shall be electrically isolated from each other with [dielectric couplings (or unions)] [flanged with gaskets] rated for the service.

Final connections to equipment shall be made with [unions] [flanges] provided every 100 feet 30480 millimeter of straight run. Unions shall be provided in the line downstream of screwed- and welded-end valves.

All pipe ends shall be reamed before joint connections are made.

Screwed joints shall be made up with specified joint compound and not more than three threads shall show after joint is made up.

Joint compounds shall be applied to the male thread only and care shall be exercised to prevent compound from reaching the unthreaded interior of the pipe.

Screwed unions, welded unions, or bolted flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

Piping systems shall be securely supported with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

Field welded joints shall conform to the requirements of the AWS WHB-2.8,

ASME B31.3, and ASME BPVC SEC IX.

[Piping systems butt weld joints shall be made with backing rings. Backing ring materials shall be compatible with materials being joined. Joint configuration shall conform to ASME B16.25.]

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NOTE: Prior to selection of one of the following two paragraphs, review requirements of ASME B31.3 And ASME BPVC SEC IX to avoid conflict and redundancy. Also review PFI ES-19 and PFI ES-28 if materials specifications have been rewritten or supplemented.

****

[Preheat and postheat treatment of welds shall be done in accordance with ASME BPVC SEC IX and ASME B31.3.]

[All necessary precautions shall be taken during installation of flexible pipe and hose including flushing and purging with water, steam, and compressed air to preclude bellows failure due to pipe line debris lodged in bellows. Installation shall conform to manufacturer's instructions.]

3.2 VALVES

Valves shall be provided in piping mains and all branches and at equipment where indicated and as specified.

Valves shall be provided to permit isolation of branch piping and each equipment item from the balance of the system.

Riser and downcomer drains above piping shutoff valves in piping 2-1/2 inches DN65 and larger shall be provided. Shutoff valve body shall be tapped and fitted with a 1/2-inch DN15 plugged globe valve.

Valves unavoidably located in furred or other normally inaccessible places shall be provided with access panels adequately sized for the location and located so that concealed items may be serviced, maintained, or replaced.

3.3 SUPPORTING ELEMENTS INSTALLATION

Supporting elements shall be provided in accordance with the referenced codes and standards.

Piping shall be supported from building structure. No piping shall be supported from roof deck or from other pipe.

Piping shall run parallel with the lines of the building. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there shall be no less than 1/2 inch DN15 of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

Piping support elements shall be installed at intervals specified hereinafter, at locations not more than 3 feet 900 millimeter from the ends of each runout, and not over 1 foot 300 millimeter from each change in

direction of piping.

Load rating for all pipe-hanger supports shall be based on insulated weight of lines filled with water and forces imposed. Deflection per span shall not exceed slope gradient of pipe. Supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, the allowable span shall be reduced proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET	COPPER PIPE FEET
1 and smaller	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	10	8
2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

PIPE SIZE (DN) MILLIMETER	ROD SIZE MILLIMETER	STEEL PIPE MILLIMETER	COPPER PIPE MILLIMETER
25 and smaller	10	2500	1850
32 to 40	10	3050	2500
50	10	3050	3050
65 to 90	13	3700	3700
100 to 125	16	5000	4300
150	20	5000	5000
200 to 300	22	6100	6100
356 to 457	25	6100	6100
508 and over	32	6100	6100

Vibration isolation supports shall be provided where needed. Refer to Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT where A/C equipment and piping is installed.

Vertical risers shall be supported independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Risers shall be guided for lateral stability. For risers subject to expansion,

only one rigid support shall be provided at a point approximately one-third down from the top. Clamps shall be placed under fittings unless otherwise specified. Carbon-steel pipe shall be supported at each floor and at not more than 15-foot 4572 millimeter intervals for pipe 2 inches DN50 and smaller and at not more than 20-foot 6096 millimeterintervals for pipe 2-1/2 inches DN65 and larger.

3.4 PENETRATIONS

Effective sound stopping and adequate operating clearance shall be provided to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces. Occupied spaces shall include space above ceilings where no special acoustic treatment of ceiling is provided. Penetrations shall be finished to be compatible with surface being penetrated.

[Sound stopping and vapor-barrier sealing of pipe shafts and large floor and wall openings shall be accomplished by packing to high density with properly supported fibrous-glass insulation or, where ambient or surface temperatures do not exceed 120 degrees F 49 degrees C, by foaming-in-place with self-extinguishing, 2-pound 0.9 kilogram density polyurethane foam to a depth not less than 6 inches 152 millimeter. Foam shall be finished with a rasp. Vapor barrier shall be not less than 1/8-inch 3 millimeter thick vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire stopping are a consideration, only mineral wool shall be used and openings shall also be covered with 16-gage 1.6 millimeter sheet metal.]

3.5 SLEEVES

Sleeves shall be provided where piping passes through roofs, masonry, concrete walls and floors.

Sleeves passing through steel decks shall be continuously [welded] [brazed] to the deck.

Sleeves that extend through floors, roofs, load bearing walls, and fire barriers shall be continuous and fabricated from Schedule 40 steel pipe, with welded anchor lugs. All other sleeves shall be formed by molded linear polyethylene liners or similar materials that are removable. Diameter of sleeves shall be large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and shall provide a minimum 3/8-inch 10 millimeter clearance. Sleeve size shall accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and the generation of noise.

Space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration shall be packed solid with a mineral fiber conforming to ASTM C 553 Type V (flexible blanket), (to 1,000 degrees F)(to 538 degrees C). This packing shall be provided wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction-surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration shall be filled with an elastomer calk to a depth of 1/2 inch 13 millimeter. All surfaces

to be calked shall be oil- and grease-free.

Through-Penetration fire stop materials and methods shall be in accordance with ASTM E 814 and UL 1479.

Exterior wall sleeves shall be calked watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

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NOTE: Review roof flooding provisions before revising the following paragraph.
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[Sleeve height above roof surface shall be a minimum of 12 305 and a maximum of 18 inches 457 millimeter.]

3.6 ESCUTCHEONS

Escutcheons shall be provided at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, escutcheons shall be provided on both sides of the partition. Where suspended ceilings are installed, plates shall be provided at the underside only of such ceilings. For insulated pipes, the plates shall be large enough to fit around the insulation. Escutcheons shall be chrome-plated in all occupied spaces and of size sufficient to effectively conceal openings in building construction. Escutcheons shall be firmly attached with setscrews.

3.7 FLASHINGS

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NOTE: Review roof flooding provisions.
****

[Flashings shall be provided at penetrations of building boundaries by mechanical systems and related work.]

3.8 UNDERGROUND PIPING INSTALLATION

Prior to being lowered into a trench, all piping shall be cleaned, visually inspected for apparent defects, and tapped with a hammer to audibly detect hidden defects.

Suspect cast-ferrous piping shall be further inspected by painting with kerosene on external surfaces to reveal cracks.

Defective materials found shall be distinctly marked using a road-traffic quality yellow paint; defective material shall be promptly removed from the site.

After conduit has been inspected, and not less than 48 hours prior to being lowered into a trench, all external surfaces of cast ferrous conduit shall be coated with a compatible bituminous coating for protection against brackish ground water. Application shall be single coat, in accordance with the manufacturer's instructions, to result in a dry-film thickness of not less than 12 mils 0.30 millimeter.

Excavations shall be dry and clear of extraneous materials when pipe is

being laid.

Cutting of piping shall be by wheel cutters or other machines designed specifically for that purpose. Electric-arc and oxyacetylene cutting will not be permitted.

Laying of pipe shall begin at the low point of a system. When in final acceptance position, it shall be true to the grades and alignment indicated, with unbroken continuity of invert. Blocking and wedging will not be permitted.

[Bell or grooved ends of piping shall point upstream.]

Changes in direction shall be made with long sweep fittings.

Necessary socket clamping, piers, bases, anchors, and thrust blocking shall be provided. Rods, clamps, and bolting shall be protected with a coating of bitumen.

Underground piping below supported or suspended slabs shall be supported from the slab with a minimum of two supports per length of pipe. Supports shall be protected with a coating of bitumen.

On excavations that occur near and below building footings, the backfilling material shall consist of 2,000-psi 13800 kilopascal cured compressive-strength concrete poured or pressure-grouted up to the level of the footing.

Vertical downspouts; soil, waste, and vent stacks; water risers; and similar work shall be properly supported on approved piers at the base and provided with approved structural supports attached to building construction.

[Cleanout, flushing, and observation risers shall be provided.]

3.9 HEAT TRACE CABLE INSTALLATION

Heater tape shall be field applied and cut to fit as necessary, linearly along the length of pipe after piping has been pressure tested and approved by the Contracting Officer. Secure the heater to piping with [cable ties] [fiberglass tape]. Thermal insulation shall be labeled on the outside, "Electrical Heat Trace."

Power connection, end seals, splice kits and tee kit components shall be installed in accordance with IEEE Std 515 to provide a complete workable system. Connection to the thermostat and ends of the heat tape shall be terminated in a junction box. Cable and conduit connections shall be raintight.

3.10 DISINFECTION

[Water piping, including all valves, fittings, and other devices, shall be disinfected with a solution of chlorine and water. Solution shall contain not less than 50 parts per million (ppm) of available chlorine. Solution shall be held for a period of not less than 8 hours, after which the solution shall contain not less than 10 ppm of available chlorine or the piping shall be redisinfected. After successful sterilization, the piping shall be thoroughly flushed before placing into service. Flushing shall be complete when the flush water contains less than 0.5 ppm of available

chlorine. Water for disinfected will be furnished by the Government. Contractor shall be responsible for approved disposal of contaminated flush water in accordance with written instructions received from the Environmental authority having jurisdiction through the Contracting Officer and all Local, State and Federal Regulations.]

[Piping shall be flushed with potable water until visible grease, dirt and other contaminants are removed (visual inspection).]

3.11 HEAT TRACE CABLE TESTS

Heat trace cable system shall be tested in accordance with IEEE Std 515 after installation and before and after installation of the thermal insulation. Heater cable shall be tested using a [1000] [_____] vdc megger. Minimum insulation resistance shall be [20 to 1000] [_____] megohms regardless of cable length.

3.12 OPERATION AND MAINTENANCE

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Test data shall be clear and readily legible.

-- End of Section --